



**IN THE SPECIFICATION**

Page 15

**Under operation of the pump –**

Paragraph 1 line 2 change axially to radially

Line 4 change radial to axial and change axial to radial

Line 6 change axially to radially

Line 7 changed axially to radially

Page 16

Paragraph 2 line 3 change axially to radially

Page 17

Paragraph 1 line 2 change axial to radially

Line 12 change axially to radially

Line 13 change axially to radially

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Page 20 paragraph 3 line 18 change axial to radially

Page 23 Paragraph 1 line 8 change planning to planing

A clean copy is enclosed.

- 46. Wheels on carriage.
- 47. Rotating agitation bar attached to shaft 4.
- 48. Setting tank with filter.
- 49. Barge.
- 50. Anchor to seafloor.
- 51. Rotation fluid flywheel shown by crosshatch.
- 52. Hose to barge from port 26.
- 53. Tether between barge and carriage.

### **Operation of the Pump**

In Fig 1B, arrows show fluid being drawn in through intake fitting 8 in housing member I into intake plenum zone 10, whereupon the fluid is forced radially outward by the diverging shape of the intake plenum 10 caused by rotor cone 13 and housing member 1. At this point, one would expect the flow to be converted from axial to radial, except that the motion of vanes 7, shown in Fig 1A, is circular, and the passing of the vane 7 in the cylinder of revolution described by the radially inner vane 7 tips as a boundary 11 to plenum 10, creates a whirlpool effect, causing the flow direction to change from radially outward to more of a tangential direction with respect to the cylinder of revolution boundary of the intake plenum 10 caused by the vane 7 motion. This tangential direction may be enhanced by spiral vane guides 22 on intake fitting 8 shown in Fig 1C and Fig 1D, such that the intake flow is given a spiral, hence tangential component, driven by atmospheric pressure in the form of net positive suction head. Alternately, the tangential intake flow may be aided by radial vanes 14 on rotor cone 13 as shown in Fig 2B. However, it is more efficient to let atmospheric pressure be the engine driving the fluid toward a tangential intake into the channels between vans 15, than using the driven energy from the rotor.

Having achieved a fluid direction that is largely tangential, i.e. in the same rotary direction that the vanes are traveling, the fluid proceeds through the opening between vanes 7 at 11, the outer cylindrical boundary of the intake plenum 10. It is important to

note that at this entry into the fluid channels 15, between vanes 7, the vane tip 12 is tangential to 11 and so the fluid is moving in approximately the same direction as the vane tip 12. This necessarily means that not only is the direction the same, but that the velocity difference at 11 is much less than normally seen in centrifugal and other kinetic pumps. This means that the fluid enters at a velocity magnitude which is proportional to that of the net positive suction head, while the vane tip 11 velocity is the that of the vane tip at that rotor diameter caused by the rotor rotational velocity since the velocity vectors are in approximately the same direction, there is a relative velocity of tangential rotor velocity at the inner tip 12 minus the fluid velocity caused by atmospheric pressure, the NPSH. Then while the rotor is tending to intersect the tangential intake flow, it does so at a very acute angle, and beginning at NPSH velocity, crosses the boundary of the intake plenum at 11 and continues tangentially toward the outer chamber wall of housing element 1 and thus fills the space between the adjacent vanes 7, the axially outer chamber wall, and the axially inner boundary 11. It is important that the fluid is allowed to fill the chambers almost totally by force of the atmospheric engine which creates the NPSH, and not by being forced by reaction against the vanes, which can create turbulent flow, or at least cause a rolling vortex in the fluid traveling toward the outer chamber wall, which in a centrifugal 1 pump is a volute. It is also important to note that in this pump, the opening at the entrance to the channel between the vanes 15 is the distance 11, which is larger than any successive distance within the channel 15 and hence the entrance to the channel 15 is not a restriction which would cause an increase of velocity and a drop in pressure, from Bernoulli's Law, which can result in pressure of the fluid and creating cavitation. Thus cavitation is avoided by this geometry.

Then as the chambers are filled primarily by the momentum of the fluid, and since the angle on the vanes 7 increases from tangential at the fluid entrance to channel 15 to more radial at the radially outer vanes position at 19, the vanes have little direct contact with the fluid since although the vane is traveling faster than the fluid, it is also angled back starting at zero angle and increasing to about 60 degree in Fig 1A. As the fluid enters the channels 15, it begins to gain further rotational energy from containment by the vanes 7, and at the same time the fluid loses all radial velocity, unlike with centrifugal pumps.

As the fluid loses all the radial velocity and is captured by the vanes 7 and the housing 1 chamber wall, it is also captured on the radially inner surface by an isobar 16 shown by a phantom line. It is captured by the divergent force field of centrifugal force, much as a full bucket of water is contained by the convergent force field of the earth's gravity. Since the fluid is totally contained by the chamber 17 it is at rest with respect to the rotor and only has rotational velocity. As such, the pump becomes positive displacement by definition, since the fluid is contained, then displaced. This is quite similar to the displacement in an external gear pump, which is not acting against a pressure head. The contained fluid is then carried by the rotor around the cylindrical chamber wall in housing element 1 to where it is ejected by its own momentum through tangential discharge 18. Unlike centrifugal pumps, the fluid, which, is contained in the enclosed chambers 17, develops a pressure gradient due to centrifugal force, which is low at the radially inner portion of chamber 15 but high near the radially outer cylindrical wall of the chamber of housing element 1. As the enclosed chamber passes the rotary valve tangential discharge port 18, the pressure is relieved and converted into velocity. Just prior to crossing the tangential discharge port, the fluid has rotational momentum, but also, being in an enclosed rotating chamber, it has pressure due to centrifugal force. The fluid, which is contained, is at rest with respect to the rotor. But as the chamber begins to pass the port 18, it begins to lose pressure, and to gain velocity. The chamber resembles a tank with a spigot at the bottom, which is opened and a stream with velocity comes from the spigot. Then if the tank is traveling at rotor velocity, and the spigot is aimed toward the direction of motion, the velocity of the fluid will be the rotor velocity plus the spigot velocity, resulting in a very high tangential discharge velocity.

Thus, in Fig 1A, fluid enters axially but is turned to a tangential direction largely by the shaping of the flow by vacuum, fills fluid passages 15, so that fluid enters the actual pumping zone, which is bounded by vanes, largely by the atmospheric engine, whereupon the fluid is contained positively and gains rotational energy, and is then discharged tangentially. Because the discharge velocity is at the rotor tip velocity due to the containment manner, the discharge momentum is high, much higher than with a

centrifugal pump having the same rotor diameter. This results in greater head pressures, since head pressure is proportional to the square of the exit velocity. The drive system, shaft, bearings and seals are shown in Fig 1B and are typical to other figures as well.

Figure 2A shows the same basic pump as in Fig 1A, but with two discharge ports 18. Just as in Fig 1A, fluid is contained in chambers 17, bounded by the adjacent vanes 7 and the cylindrical chamber wall of housing member 1 and by the isobar 16. Provided the intake 9 is large enough to accommodate the flow, this pump will have twice the capacity of the pump of Fig 1A, provided the vane depth is the same, but it will have the same exit velocity, hence the same pressure capability. Having twice the capacity and the same pressure means it will require twice the drive power. This pump is useful for high power applications such as firefighting. The alternate rotor design shown in Fig 2B and 2C has small radial vanes to aid in the creation of a whirlpool effect and tangential intake to the fluid channel entrance 16. The side view is similar to Fig 1B.

Figure 3A is similar to Fig 1A except for the vanes 7 shape the fluid channel 15, and the shape of the enclosed chamber 17 when bounded by isobars. In Fig 3A, the fluid is drawn into the channels 15, which end being the enclosed chambers 17. In this case, the enclosed chamber 17 has a portion on the periphery next to the cylindrical chamber wall of housing element 1. This means the fluid, which is contained in the peripheral part of chamber 17, is at the maximum energy state, being at the maximum rotor speed, which is at vane tip at 19. All the fluid that is contained in the enclosed peripheral chamber 17 will discharge tangentially by momentum through tangential discharge port 18, but none of the other fluid, or at least very little, located in channel 15 will be discharged, but will fill the part of chamber 17 which has already been discharged. In this way, the contained fluid is metered out much as other positive displacement pumps and the capacity can be calculated as being proportional to the volume of the peripheral containment times the rotational velocity, i.e., the cubic inch displacement volume x the rpm divided by 231 cubic inches per gallon gives gallons per minute. This allows one to accurately prescribe the pump capacity. It is a primary objective to not only prescribe the capacity, but to be able to reduce the capacity while maintaining the fluid velocity so as to gain head

pressure without excess capacity, hence excess power requirement. The geometry of fig 3A allows continuous discharge except of the small interruption at each vane tip. Shown are 3 vanes 7 and 3 channels 15 as well as 3 enclosed volumes 17. This number can be increased or can be decreased to as few as one. The number of vanes in Fig 1A can be as few as two but in Fig 2A, four vanes are required in order to enclose the chamber 17.

Having the capacity easily regulated as in Fig 3A, allows the output flow to be decreased as much as desired by simply making the chambers 17 small in cross-section. This allows either an increase in rotor diameter, or an increase in rotation speed, either of which will result in increased fluid velocity and head pressure and with a corresponding decrease in capacity so that the drive power remains constant. This allows very high head pressure without staging. The side view of fig 3A is similar to Fig 1B.

Fig 4A is another front view with vanes 7 which are tangent at 11, but curved and more perpendicular to the cylindrical inner chamber surface of housing member 1 at 19. The operation of the embodiment is similar to that of both Fig 1A and Fig 2A except that Fig 4A has 3 tangential discharge ports feeding into discharge. The discharge 18 has 3 feeder ports through housing member 1 such that there is always a momentary capture of the fluid 17 where boundary isobar 16 exists. This is true for each of the three sectors between discharge ports such that the length of each sector is no longer than the distance between vane tips, as there are four vanes 7 but only 3 discharge ports. The final discharge is the sum of the 3 flows and gives the discharge a stepped volute shape. Because the fluid is trapped prior to discharge and reaches rotor velocity, the pressure will be similar to that of the pump in Fig 1, but the capacity will be greater. The arrows shown in fig 4A are meant to show the flow direction of the fluid through the pump. The side view is similar to Fig 1B.

Fig 5A is a front view of a pump which may have a vane configuration similar to that in either Fig 1A, Fig 3A or Fig 4A but shows a different means of achieving the tangential intake flow. The fluid in Fig 5A enters tangentially from the side rather than axially as in Fig 1a, 2A, 3A and 4A. The intake plenum 10 has an intake volute, which forces the fluid

into a circular motion such that it leaves the intake plenum 10 tangentially and from that point on is similar to the flow in Fig 1A, Fig 2A, Fig 3A, Fig 4A as it becomes captured in enclosed chambers, reaches rotor rotational velocity and is discharged through tangential discharge 18. The arrow shown in Fig 5A, shows the path of the fluid through the pump.

Fig 5B shows a plan view where the fluid enters at 11, tangentially is guided by a volute at 20 so as to enter intake plenum 10 tangentially where it is again captured in an enclosed volume, reaches rotor rotational velocity, and is discharged at 18. The discharge shown in this view is a variation and shows it may be discharged tangentially, but out the side with a small axial component.

Fig 5C shows the same plan view of the pump, but shows it as a motor, the fluid enters the pump in the same manner as in 5B, except the entering fluid is high pressure fluid having high velocity. Again, the fluid is acted on by a volute to send it into a circular whirlpool at 20 into intake plenum 10 tangentially, but at high velocity, where it enters the passage between vanes. Multiple tangential intake ducts may be used to advantage. However, as a motor, the vane shape should be similar to the shape 21 shown in Fig 5E. Note that as a motor, the vane configuration is more resembling that of a centrifugal pump. The fluid enters the passage channels 15 at an angle, which is not exactly tangential, but leaves the pump housing member 1 tangentially. With the motor vanes 19, the fluid is leaving the intake plenum 10 tangentially but at the stopped rotor position sees the channel passage 15 as at head pressure. But as the rotor begins to turn by tangential jet action, the apparent angle between the intake flow and the vane begins to change from initially a reverse direction acute angle, toward a 90-degree angle. While this is happening, the rotor is increasing in speed and the pressure is changing to velocity and as the rotor reaches speed the fluid at intake plenum 10 is at lower pressure, but high rotational velocity. As the fluid leaves intake plenum tangentially, it acts against the motor vanes 19 such as to cause the rotor to rotate and provide torque. The momentum of the fluid is, slowed by vanes 19, both in the radially outward direction and tangentially, such that it may leave the rotor into discharge port 18 tangentially with a high velocity

with respect to the vane tips, but with little or no ground speed. In this way it is acting in a similar manner to the propeller type hydro turbines where the fluid acts directly against a blade. While the propeller is working in an axial direction, this device works in both a radial and tangential direction. The discharge, although tangential, can also be 360 degrees as shown in Fig 5D, which means that as a motor, the fluid is not captured as it was in the previous pump embodiments, but the fluid is always in continual motion with respect to the rotor and the channel 15 between vanes and there is no captured volume 17. At start up, with the rotor at zero velocity, pressure forms in the intake plenum 10 and the fluid has to be ejected through the fluid passages 15 which provides, torque by thrust exerted on the rotor. At this point of operation, the torque is quite high, but the power is low due to no rotational speed. As the rotor gains rotational velocity, the manner in which the torque is generated changes from jet reaction to force against a rotor member and in this way is similar to both the Pelton wheel and the axial propeller motor. The difference between this and a Pelton wheel is that this concept allows a high flow rate as well as a high specific speed. The rotor speed, which is a result of velocity from the head pressure of  $V^2 = 2gH$  is quite high since the fluid is entering nearer to the axis of rotation. This means the fluid velocity within the channel passages 15 is high with respect to the rotor, but the fluid velocity with respect to the earth is slowed to near zero by the vanes, this slowing causing torque to the rotor. This is in some ways opposite to a Francis reaction turbine, where the fluid enters the rotor channels as tangentially as possible and is discharged axially, the torque being provided by the change in angular momentum from high momentum to low momentum.

However, the result is the same, the momentum of the fluid is decreased resulting in torque and work being done by the motor. The rotational speed the rotor may attain is largely a function of the pitch of vanes 19. If the trajectory of the pressure fluid is tangential, it must totally reverse its direction and leave the channels 15 tangentially in the opposite direction. However, the fluid is inertial and tends to proceed tangentially in the direction it left from intake plenum 10 traveling only a short distance in which it loses its momentum. But to achieve that, the rotor vanes 19, as shown in Fig 5d must travel 90 degrees indicating that the rotor tip velocity is considerably greater than the fluid head



velocity, which is unusual in the art. This means the specific speed is expected to be high. Thus in Fig 5A, Fig 5B the fluid enters tangentially into the rotor pumping channels where it gains rotational energy by moving to a larger diameter and higher velocity and leaves the pump tangentially. It enters tangentially, is accelerated to a higher velocity by the rotor channels 15 and enclosed chamber and leaves tangentially in the same rotational direction. As a motor, the fluid enters tangentially, is slowed in the channels between vanes 15 and is also discharged tangentially but in the opposite direction.

Fig 5E is a front view of a pump shown in Fig 5A used as a slurry or sludge pump. Fig 5E shows a large intake duct 9 with a valve 37 through which the slurry is drawn into the pump. There are also secondary intake ducts 27 which communicate both with the intake duct 9 and with the intake plenum 10 which have valves 27 and can be connected to a water source. In order to start the pump, the main intake valve 37 is closed and the secondary water valves 27 are opened, and the pump is primed and started pumping water. Then the main intake valve is opened and the secondary water valves are partially closed. The water is pumped and a strong vacuum is formed at 9, causing the slurry to be accelerated toward the intake plenum 10. The slurry continues by inertia into intake plenum 10 and on to be intercepted by vanes 7 which intercept the incoming slurry at an acute angle and captures the slurry in fluid passages 15 as typically shown in Fig 1A and Fig 1B. Because the slurry has a higher density than water, it is thrown out of tangential discharge port 18 at a higher momentum than would normally be seen with centrifugal pumps and this results in a lower pressure or greater vacuum seen in intake plenum 10 which facilitates the pumping due to a higher pressure difference within the pump. Valves 27 can regulate the slurry flow and consistency.

Fig 6A shows a front view of a double intake, double discharge version of Fig 5A. Fluid enters tangentially through the side at 20 into intake plenum 10. Guided by half circle volutes such that a whirlpool exists in intake plenum 10 and it is drawn in the channels between vanes 15 where it is contained, gains rotor velocity and momentum and is discharged through tangential discharge ports 18.

Fig 6B is a side view showing many of the same parts with the same functions as previously discussed. The arrows show the path of the fluid through the pump. This is a very high power device, suitable for liquid jet propulsion. If this pump is positioned in a boat such that there are intake ducts through the bottom of the vessel with the ducts going aft into the pump intakes 20 and the discharge ducts 18 turned to exit aft of the vessel, thrust will be obtained. An advantage of this type of marine drive is that the fluid momentum increases as the cube of the rpm and experiment shows it may be more than the cube. This is of considerable advantage to a high speed, planing vessel, since the vessel engine at high rpm will be delivering high power to the fluid, due to the exponential relationship of the rpm vs. torque curve. In an axial turbine, the torque is linear, and due to the intake speed, very little power is delivered to the fluid even through the engine is racing. In this design, full power can be delivered. Fig 6A can also be a motor, provided the intake ducts are smaller compared to discharge, and if the Fig 5D type rotor is used.

Fig 7A shows the pump as in Fig 6A and Fig 6B in a plan view of a boat 33. The pump is mounted fixed to the stern area of the boat at 36 being driven by engine 38. Intake ducts 35 come through the bottom of the boat 34 into the pump and discharge ducts 18 provide thrust to the boat. Valves 37 on the discharge may be used to steer the vessel. Discharge ducts may be turned to reverse the boat.

Fig 7B shows a pump as in Fig 5A and Fig 5B mounted on an out board motor 39 for rotation and the outboard mounted to a boat stern 41. The handle for steering and throttle is 40. The pump has an intake 42 facing forward in the boat and a discharge 43 facing aft.

Fig 8A is a front sectional view of a multiple purpose pump which has a vane and rotor configuration similar to Fig 6A and Fig 6B, but Fig 8A and Fig 8B show multiple discharge ports which are located at different axial distances from the axis of revolution determines the fluid velocity and head pressure, the three ports shown represent different fluid pressure at the same rotational speed of the rotor.

Fluid enters at intake port 10 and is discharged in one of the three ports 30, 31, or 32, in which the fluid exits the fluid chamber 15 tangentially, but with also an axial component. The ducts leading from ports are equipped with valves, such as ball valves, as shown in Fig 8C, 8D, 8E, 8F, 8G, 8H.

Fig 8B is a sectional side view of Fig 8A.

Fig 8C illustrates the operation of the pump in the high pressure, low flow mode. Fluid enters chamber 10 with valves 37 open and is pumped out through discharge port 32 with the valves 37 on ports 30 and 31 closed. Because of the port location and the tapering of the pumping chamber, the pressure will be high since the tangential velocity is at a maximum at this point.

Fig 8D shows valves 37 at 10 and 31 open and closed at 30 and 32. In this position, the flow is increased over Fig 8C but the pressure is decreased due to the fluid velocity being determined by the rotor diameter at port 31. The flow is increased due to longer ports and a wider fluid chamber between vanes. So that this represents a medium pressure, medium flow. The shaded portion represents a fluid flywheel bounded by an isobar.

Fig 8E shows the valves 37 at intake 10 open, the valves 37 at 32 and 31 are closed such that fluid enters at 10 and discharged through port 30 at a higher flow rate, but with less pressure.

By having ports 30 and 31, the efficiency of the pump is increased if the pressure requirement is low and the pump is discharging at 32, there is no point to the high velocity since it consumes power as power consumption is proportional to flow times pressure, so while the pump described in Fig 1A is quite efficient at higher head pressures, it is not efficient at lower head pressures, whereas the pump shown in 8A and 8B is efficient over a range of flow rates and head pressures and gives the user some very good options. In Fig 8E, the shaded areas show the revolving liquid flywheel has expanded and the pump doesn't operate in the shaded areas.

Fig 8F and Fig 8G show some interesting features of priming. If the pump is filled and the fluid circuit is as shown in Fig 8F with valves 37 open at discharge ports 30 and 31 and closed at intake 37 at 10 and discharge valves 37 and 32, and the pump in a loop such that port 30 has changed from a discharge to has changed from a discharge to an intake. Then if the two valves 37 are cracked at intake 10 and discharge 32, the pump can prime and once primed, the choice of valves to close can be made.

Figure 8H shows the pump operating partly as a centrifuge in order to separate fluids of different densities or denser solids from the fluid, such as pumping dirty fuel and having the dirty part discharged through a bleed valves 37 at discharge port 32, and the clean fuel being discharged through discharge port 31.

The shape of the pumping chamber pumping chamber housing is such that the centrifugal force which is developed within the fluid passages 15 between vanes 7 as shown in will cause more dense matter to accumulate along the boundary between vanes 7 and housing member 1 at 33 in Fig 8B, and then is carried on to discharge port 32, where it may be bled off.

Fig 9 shows a front view of a pump similar to that of Fig 1A, except that there are two discharge ports, the discharge port 32 being at the isobar of highest pressure, and the port 31 being located on an isobar of less pressure, and the discharge port 31 is fitted with a valve 37 to regulate flow.

Fig 9B is a side view of Fig 9A. A contaminated fluid, such as petroleum and water with rust, is drawn in through the inlet fitting 8 where it begins to acquire spin in the direction of rotation of rotor 3. The rotor and vanes are angled more than those shown in Fig 1A and Fig 1B and that is to begin the fluid separation of petroleum and the contaminants on the inclined surface shown at 33, such that when acquiring angular velocity, the more dense particles and fluids migrate to the axially outer surface 33. As the rotation continues, the denser elements arrive at the highest pressure isobar, at 25, where they

continue by momentum into discharge port 32 and to flow restricting valve 37 shown in Fig 9A. Depending on the ratio of contaminants to clean petroleum will determine the opening in the valve. If the valve is closed, the contaminants will simply accumulate in port 32 up to valve 37 as a sump. If valve 37 is opened, some clean fuel will pass through valve 37, and the remainder will be pumped through port 31.

Fig 9D shows 9B opened and the pump 36, discharges clean petroleum through port 31 and the contaminated fluid through 32. I have interposed 48, a settling tank between 32 and 37 which when valve 37 is closed can be a sump and when open 48 is a settling tank and filter, so that the filtered fuel may be returned to the intake source at 20 if desired.

Fig 9C is a variation of Fig 9B which shows a tangential intake means similar to that shown in Fig 5A, with the objective that not only are particles within the fluid being separated by density, but the pump supplies a motor force by jet action such as in Fig 7B.

Fig 10 is a plan view of one use of the pump in Fig 9C, as a gold dredge, which operates similar to a pool sweep. In Fig 10, the pump 36 is mounted on carriage frame 43 having wheels 46 which allow the carriage to roll on the sea floor. Also mounted on the carriage is a hydraulic drive motor 44, which is coupled to pump 36 and also the drive shaft has an agitator rod 47 fixed to the shaft to strike and disturb the sand sea floor. The carriage is tethered to a barge 49 anchored by anchor 50. The rotation of the shaft 4 and the bar 47 causes sand to be thrown upward where it is sucked into the water intake of pump 36 at intake duct 42. The water and sand passes through pump 36 and the water and the less dense sand particles are discharged through discharge 31 and the more dense flour gold is collected in discharge hose 52 which terminates in Barge 49, and at the same time the carriage is moved forward in an arc in the direction of the arrow by the jet action of pump 36.